HISTORY OF THE NAMES CAMBRIAN AND SILURIAN IN GEOLOGY*

(*Concluded from page* 37)

THE Lingula flags and Tremadoc slates have been made the subject of careful stratigraphical and palæontological studies by the Geological Survey, the results of which are set forth by Ramsay and Salter in the third volume of the Memoirs of the Geological Survey, published in 1866, and also, more concisely, in the Anniversary Address by the former to the Geological Society in 1863. (Geol. Jour. XIX. xviii.) The Lingula flags (with the underlying Menevian, which resembles them lithologically) rest in apparent conformity upon the purple Harlech rocks both in Pembrokeshire and in Merionethshire, where the latter appear on the great Merioneth anticlinal, long since pointed out by Sedgwick. The Lingula flags (including the Menevian), have in this region, according to Ramsay, a thickness of about 6,000ft. Above these, near Tremadoc and Festiniog, lie the Tremadoc slates, which are here overlain, in apparent conformity, by the Lower Llandeilo beds. At a distance of eleven miles to the north-west, however, the Tremadoc slates disappear, and the Lingula flags are represented by only 2,000ft. of strata; while in parts of Caernarvonshire and in Anglesea the whole of the Lingula flags and moreover the Lower Cambrian rocks are wanting, and the Llandeilo beds rest directly upon the ancient crystalline schists. In Scotland and in Ireland, moreover, the Lingula flags are wholly absent, and the Llandeilo rocks there repose unconformably upon grits regarded as of Lower Cambrian age. Thus, without counting the Tremadoc slates, which are a local formation unknown out of Merionethshire, we have (including the Bangor group and Lingula flags) beneath the Llandeilo, over 9,000ft. of fossiliferous strata, which disappear entirely in the distance of a few miles. From a careful survey of all the facts, the conclusion of Ramsay is irresistible, that there exist between the Lingula flags and the Llandeilo not merely one, but two great stratigraphical breaks in the succession; the one between the Lingula flags and the Lower Tremadoc slates, and the other between the Upper Tremadoc slates and the Lower Llandeilo.

This conclusion is confirmed by the fact that there exists at each of these horizons a nearly complete palæontological break. The fauna of the Tremadoc slates is, according to Salter, almost entirely distinct from that of the Lingula flags, and not less distinct from that of the so-called Lower Llandeilo or Arenig rocks (the equivalents of the Skiddaw slates of Cumberland). Hence, says Ramsay, it is evident "that in these strata we have three perfectly distinct zones of organic remains, and therefore, in common terms, three distinct formations." The palæontological evidence is thus in complete accordance with that furnished by stratigraphy. We cannot leave this topic without citing the conclusion of Ramsay, that "each of these two breaks necessarily implies a lost epoch, stratigraphically quite unrepresented in our area; the life of which is only feebly represented in some cases by the fossils common to the underlying and overlying formation." In connection with this remark, which we conceive to embody a truth of wide application, it may be said that stratigraphical breaks and discordances in a geological series may, *a priori*, be expected to occur most frequently in regions where this series is represented by a large thickness of strata. The accumulation of such masses implies great movements of subsidence, which, in their nature, are limited, and are accompanied by elevations in adjacent areas, from which may result, over these areas, either interruptions in the process of sedimentation, or the removal, by sub-aerial or sub-marine denudation, of the sediments already formed. The conditions of succession and distribution, it may be conceived, would be very different in a region where the period corresponding to this same geological series was marked by comparatively small accumulations of sediment upon an ocean-floor subjected to no great movements.

This contrast is strikingly seen between the conformable series of less than 2,000 feet of strata which in Scandinavia are characterised by the first three palæozoic faunas (Cambrian and Silurian) and the repeatedly broken and discordant succession of more than 30,000 feet of sediments† which in Wales are their palæontological equivalents. It must, however, be considered that in regions of small accumulation where, as in Scandinavia, the formations are thin, there may be lost or unrepresented zoological epochs whose place in the series is marked by no stratigraphical break. In such comparatively stable regions, movements of the surface sufficient to cause the exclusion, or the disappearance by removal, of the small thickness of strata corresponding to an epoch, may take place without any conspicuous marks of stratigraphical discordance.

The attempt to establish geological divisions or horizons upon stratigraphical or palæontological breaks must always prove fallacious. From the nature of things, these, whether due to non-deposition or to subsequent removal of deposits, must be local; and we can say confidently that there exists no break in life or in sedimentation which is not somewhere filled up and represented by a continuous and conformable succession. While we may define one period as characterised by the presence of a certain fauna, which, in a succeeding epoch, is replaced by a different one, there will always be found, in some parts of their geographical distribution, a region where the two faunas commingle, and where the gradual disappearance of the old before the new may be studied. The division of our stratified rocks into systems is therefore unphilosophical, if we assign any definite or precise boundaries or limitations to these. It was long since said by Sedgwick with regard to the whole succession of life through geologic time—that all belongs to one great *systema naturæ*. (Philos. Mag. IV. viii. 359.)

We have already noticed that Barrande, as early as 1852, gave the name of Primordial Silurian to the rocks which, in Bohemia, were marked by the first fauna; although he, at the same time, recognised this as distinct from and older than the second fauna, discovered in the Llandeilo rocks, which Murchison had declared to represent the dawn of organic life. Into the reasons which led Barrande to include the rocks of the first, second, and third fauna in one Silurian system (a view which was at once adopted by the British Geological Survey and by Murchison himself), it is not our province to inquire; but we desire to call attention to the fact that the latter, by his own principles, was bound to reject such a classification. In his address before the Geological Society in 1842 (already quoted in the first part of this paper) he declared that the discussion as to the value of the term Cambrian involved the question "whether there was any type of fossils in the mass of the Cambrian rocks different from those of the Lower Silurian series. If the appeal to nature should be answered in the negative, then it was clear that the Lower Silurian type must be considered the true base of what I had named the protozoic rocks; but if characteristic new forms were discovered, then would the Cambrian rocks, whose place was so well established in the descending series, have also their own fauna, and the palæozoic base would necessarily be removed to a lower horizon."

In the event of no distinct fauna being found in the Cambrian series, it was declared that "the term Cambrian must cease to be used in zoological classification, it being in that sense synonymous with Lower Silurian." (Proc. Geol. Soc. iii. 641 *et seq.*) That such had been the result of palæontological inquiry Murchison then proceeded to show. Inasmuch as the only portion of Sedgwick's Cambrian which was then known to be fossiliferous, was really above and not below the Llandeilo rocks, which Murchison had taken for the base of his Lower Silurian, his reasoning with regard to the Cambrian nomenclature, based on a false datum, was itself fallacious; and it might have been expected that when the Government surveyors had shown his stratigraphical error, Murchison would have rendered justice to the nomenclature of Sedgwick. But when, still later, a farther "appeal to nature" led to the discovery of "characteristic new forms," and established the existence of a "type of fossils in the mass of the Cambrian rocks different from those of the Lower Silurian series," Murchison was bound by his own principles to recognise the name of Cambrian for the great Festiniog group, with its primordial fauna, even though Barrande and the Government surveyors should unite in calling it Primordial Silurian.

He however chose the opposite course, and now attempted to claim for the Silurian system the whole of the Middle Cambrian or Festiniog group of Sedgwick, including the Tremadoc slates and the Lingula flags. The grounds of this assumption, as set forth in the successive editions of "Siluria" from 1854 to 1867, and in various memoirs, may be included under three heads: first, that the Lingula flags have been found to exist in some parts of his original Silurian region; second, that no clearly-defined base had been assigned by him to his so-called system; and third, that there are no means of drawing a line of demarcation between these Middle Cambrian formations and the overlying Llandeilo.

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† The Longmynd rocks in Shropshire are alone estimated at 20,000 feet; but their supposed equivalents, the Harlech rocks of Pembrokeshire, have a measured thickness of 3,300, while the Llanberis and Harlech rocks together, in North Wales, equal from 4,000 to 7,000 feet, and the Lingula flags and Tremadoc slates, united, about 7,000 feet. The Bala group in the Berwyns exceeds 12,000 feet, and the proper Silurian, from the base of the Upper Llandovery or May Hill sandstone, attains from 5,000 to 6,000 feet; so that the aggregate of 30,000 feet may be considered below the truth. (Mem. Geol. Survey, iii. part 2, pages 72, 222, and Siluria, 4th ed. 185.)

With regard to the first of these reasons, it is to be said that the only known representatives of the Lingula flags in the region described by Murchison in his "Silurian System" are the black slates of Malvern, and some scanty outliers which, in Shropshire, lie between the old Longmynd rocks and the base of the Stiper-stones. The former were then (as has already been shown) supposed by him to belong to the Llandeilo, or rather to the passage-beds between the Llandeilo and Cambrian (Bala); while with regard to the latter, Ramsay expressly tell us that they were not originally classed with the Silurian, but have since been included in it. (Mem. Geol. Sur. iii. part 2, page 9; and 242, foot-note.)

The Llandeilo beds were by Murchison distinctly stated to be the base of the Silurian system (Sil. Sys. 222); and it was further declared by him that in Shropshire (unlike Caermarthenshire) "there is no passage from the Cambrian to the Silurian strata," but a hiatus, marked by disturbances which excluded the passage-beds, and caused the Lower Silurian to rest unconformably upon the Longmynd rocks. (Ibid, 256; and plates 31, sections 3 and 6; 32, section 4.) But in "Siluria" (1st ed. 47) the two are stated to be conformable; and in the subsequent sections of this region, made by Aveline, and published by the Geological Survey, the evidences of this want of conformity do not appear. Murchison at that time confounded the rocks of the Longmynd with the Cambrian (Bala) beds of Caermarthenshire and Brecon. (Sil. Sys. 416). Hence it was that he gave the name of Cambrian to the former; and this mistake, moreover, led him to place the Cambrian of Caermarthenshire beneath the Landeilo. It is clear that if he claimed no well-defined base to the Llandeilo rocks in this latter (their typical region), it was because he saw them passing into the overlying Bala beds. There was, in the error by which he placed *below* the Llandeilo, strata which were really *above* them, no ground whatever for afterwards including in his Silurian system, as a downward continuation of the Llandeilo rocks (which are the basal portion of the Bala group), the whole Festiniog group of Sedgwick; whose infra-position to the Bala had been shown by the latter long before it was known to be fossiliferous.

It was, however, claimed by Murchison that no line of separation can be drawn between these two groups. The results of Ramsay and of Salter, as set forth in the address of the former before the Geological Society in 1863, and more fully in the Memoirs of the Geological Survey (vol. iii. part 2) published in 1866, with a preface by himself, as the director of the Survey, are completely ignored by Murchison. The reader familiar with these results, of which we have given a summary, finds with surprise that in the last edition of "Siluria," that of 1867, they are noticed in part, but only to be repudiated. In the five pages of text which are there given to this great Middle Cambrian division, we are told that the distinction between the Lower Tremadoc and the Lingula flags "is difficult to be drawn," and that the Upper Tremadoc slate passes into and forms the lower part of the Llandeilo, "into which it graduates conformably" ("Siluria," 4th ed. p. 46). In each of these cases, on the contrary, according to Ramsay, there is observed "a break very nearly complete both in genera and species, and probable unconformity;" the evidence of the palæontological break being furnished by the careful studies of Salter; while that of the stratigraphical break, as we have seen, leaves no reason for doubt. (Mem. Geol. Sur. iii. part 2, pp. 2, 161, 234). The student of "Siluria" soon learns that in all cases where Murchison's pretensions were concerned, the book is only calculated to mislead.

The reader of this history will now be able to understand why, notwithstanding the support given by Barrande, by the Geological Survey of Great Britain, and by most American geologists, to the Silurian nomenclature of Murchison, it is rejected, so far as the Lingula-flags and the Tremadoc slates are concerned, by Lyell, Phillips, Davidson, Harkness, and Hicks in England, and by Linnarsson in Sweden. These authorities have, however, admitted the name of Lower Silurian for the Bala group or Upper Cambrian of Sedgwick; a concession which can hardly be defended, but which apparently found its way into use at a time when the yet unravelled perplexities of the Welsh rocks led Sedgwick himself to propose, for a time, the name of Cambro-Silurian for the Bala group. This want of agreement among geologists as to the nomenclature of the lower palæozoic rocks, causes no little confusion to the learner. We have seen that Henry Darwin Rogers followed Sedgwick in giving the name of Cambrian to the whole palæozoic series up to the base of the May Hill sandstone; and the same view is adopted by Woodward in his Manual of the Mollusca. The student of this excellent book will find that in the tables giving the geological range of the Mollusca, on pages 124, 125, and 127, the name of Cambrian is used in Sedgwick's sense, as including all the fossiliferous strata beneath the May Hill sandstone. On page 123 it is however explained that Lower Silurian is a synonym for Cambrian, and it is so used in the body of the work.

The distribution of the Lower and Middle Cambrian rocks in Great Britain may now be noticed. The former, or Bangor group, to which Murchison and the Geological Survey restrict the name of Cambrian, and which they sometimes call the Longmynd, bottom or basement rocks, occupy two adjacent areas in Caernarvon and Merionethshire; the one near Bangor, including Llanberis, to the north-east, and the other, including Harlech and Barmouth, to the south-east of Snowdon; this mountain lying in a synclinal between them, and rising 3,571 feet above the sea. The great mass of grits or sandstones appears to be at the summit of the group, but in the lower part the blue roofing slates of Llanberis are interstratified in a series of green and purple slates, grits, and conglomerates (some of the Welsh roofing-slates are, however, supposed to belong to the Llandeilo). (Mem. Geol. Survey iii. part 2, pages 54, 258). The Harlech rocks in this north-western region are conformably overlaid by the Menevian, followed by the true Lingula-flags, or Olenus beds, of the Middle Cambrian. Upon these repose the Tremadoc slates, which are not known in the other parts of Wales. The third area of Lower Cambrian rocks is that already described at St. David's in Pembrokeshire, about 100 miles to the south-west; and the fourth, that of the Longmynd hills, about sixty miles to the south-east of Snowdon. The rocks of the Longmynd, like those of the other Lower Cambrian areas mentioned, consist principally of green and purple sandstones with conglomerates, shales, and some clay-slates. They occasionally hold flakes of anthracite, and small portions of mineral pitch exude from them in some localities. The only evidence of animal life yet found in the rocks of the Longmynd is furnished by worm-burrows, the obscure remains of a crustacean (the *Palæopyge Ramsayi*) and a form like *Histioderma*. This latter organic relic, with worm-burrows, and the fossils named *Oldhamia*, is found on the coast of Ireland opposite Caernarvonshire, in the rocks of Bray Head; which resemble lithologically the Harlech beds, and are regarded as their equivalents.

Still another area of the older rocks is that of the Malvern hills, on the western flanks of which, as already mentioned, the Lingula flags are represented by about 500 feet of black shales with *Olenus*, underlain by 600 feet of greenish sandstones containing traces of fucoids, with Serpulites and an *Obolella*. It is not improbable, as suggested by Barrande and by Murchison, that these 1,100 feet of strata represent, in this region, the great mass of the Lingula flags, and, we may add, perhaps the whole series of Lower Cambrian strata, which in Caernarvonshire and Pembrokeshire underlie them; since these sandstones of Malvern, like those of St. David's, rest upon crystalline schists, and are in part made up of their ruins.

These crystalline schists of Malvern, which are described by Phillips as the oldest rocks in England, and by Mr. Hull are conjectured to be Laurentian, seem, from the descriptions of their lithological characters, to resemble those of Caernarvon and Anglesea, with which they are, by Murchison, regarded as identical. The crystalline schists of these latter localities are by Sedgwick described as hypozoic strata, below the base of the Cambrian. Murchison, however, in the first edition of his "Siluria," adopted the suggestion of De la Beche that they themselves were altered Cambrian strata. In fact, they directly underlie the Llandeilo rocks, and were apparently conceived by Murchison to represent the downward continuation of these, upon which he had insisted. This opinion is supported by ingenious arguments on the part of Ramsay (Mem. Geol. Survey, iii. part 2, *passim*). I am however disposed to regard them, with Sedgwick and Phillips, as of pre-Cambrian age, and to compare them with the Huronian series of North America, which occupies a similar geological horizon, and with which, as seen in northern Michigan, and in the Green Mountains, I have found the rocks of Anglesea to offer remarkable lithological resemblances.

It may here be noticed that the gold-bearing quartz veins in North Wales are found in the Menevian beds, and also, according to Selwyn, throughout the Lingula flags. These fossiliferous strata at the gold mine near Dolgelly appear in direct contact with diorites and chloritic and talcose schists, which are more or less cupriferous, and themselves also contain gold-bearing quartz veins (Mem. Geol. Survey, part 2, pp. 42, 45, and Siluria, 4th ed., 450, 547).

The following table gives a view of the lower palæozoic rocks of Great Britain and North America, together with the various nomenclatures and classifications referred to in the preceding pages. In the second column, the horizonal black lines indicate the positions of the three important palæontological and stratigraphical breaks signalised by Ramsay in the British succession (Mem. Geol. Survey, iii. part 2, page 2). In a table by Davidson in the *Geological Magazine* for 1868 (v. 305) showing the distribution of organic remains in these lower rocks, he gives, as the Festiniog group of Sedgwick, only the Dolgelly and Maentwrog beds of Belt (the Upper and Middle Lingula flags), and makes of the two divisions of the Tremadoc rocks a separate group; the whole being described as the Upper Cambrian of Sedgwick. This, however, is not the present grouping and nomenclature of Sedgwick, nor was it his earlier one. So far as regards Middle and Upper Cambrian, this discrepancy is explained by the fact already stated, that in 1843 Sedgwick proposed as a compromise the name of Cambro-Silurian for his Bala group, previously called Upper Cambrian; by which change the Festiniog or Middle Cambrian became Upper Cambrian. When the true relation between the Lower Silurian of Murchison and the Bala group was made known, Sedgwick, as we have seen, re-claimed for the latter his former name of Upper Cambrian; but this had meanwhile been adopted for the Festiniog group, in which sense it is still used by Lyell, Phillips, Davidson, Harkness, and Hicks. The Festiniog group, or Middle Cambrian, as defined by Sedgwick, however, included not only the whole of the Lingula flags, but the Upper and Lower Tremadoc rocks (Philos. Mag. IV. viii, 362).

LOWER PALÆOZOIC ROCKS OF EUROPE AND NORTH AMERICA

	BRITISH SUB DIVISIONS.	NORTH AMERICAN SUB-DIVISIONS.	NOMENCLATURES OF SEDGWICK AND MURCHISON.	BARRANDE'S CLASSIFICATION.	ANGELIN'S DIVISIONS.
14	Ludlow.	Lower Helderberg.	Silurian, *Sedgwick*. Upper Silurian, *Murchison*.	Third fauna, including Etages H, G, F, E.	VIII. VII., or Regiones E, and DE.
13	Wenlock.	Niagara, Clinton,			
12	Upper Llandovery.	Medina, Oneida.			
11	Lower Llandovery.	Hudson-River, Utica,	Upper Cambrian or Bala group, *Sedgwick*. Lower Silurian, *Murchison*.	Second fauna, including Etage D.	VI. V. IV., or Regiones D, C, and BC.
10	Caradoc.	Trenton, Birdseye,			
9	Upper Llandeilo.	Black-River.			
8	Lower Llandeilo.	Chazy.			
7	Upper Tremadoc.	Levis.	Middle Cambrian or Festiniog group, *Sedgwick*. Primordial Silurian, *Murchison*.	First fauna, or Primordial fauna, including Etage C, and probably also Etage B.	III. II. I., or Regiones B, and A, and Regio Fucoidarum.
6	Lower Tremadoc.	Calciferous.			
5	Dolgelly.	Potsdam.			
4	Maentwrog.				
3	Menevian.	Braintree and St. John.	Lower Cambrian or Bangor group, *Sedgwick*. Cambrian, *Murchison*.		
2	Harlech.	——— ?			
1	Llanberis.	——— ?			

The only change which I have made in the groupings of the British rocks adopted by Sedgwick and by Murchison, is in separating the Menevian or Lower Lingula flags from the Festiniog, and uniting it with the Bangor group or Lower Cambrian. In this I follow, with Lyell and Davidson, the suggestion of Salter and Hicks.

In the third column, the sub-divisions are those of the New York and Canada Geological Surveys; in connection with which the reader is referred to a table published in 1863, in the "Geology of Canada," p. 932. Opposite the Menevian I have placed the names of its principal American localities, which are Braintree, Mass., St. John, New Brunswick, and St. John's, Newfoundland. With regard to the classification of Angelin, it is to be remarked that, although he designates II. as *Regio Olenorum*, and III. as *Regio Conocoryphorum*, the position of these, according to Linnarsson, is to be reversed; the Conocoryphe beds with *Paradoxides* being below, and not above, those holding *Olenus*. The *Regio Fucoidarum* in Sweden has lately furnished a brachiopodous shell, *Lingula monilifera*, besides the curious plant-like fossil, *Eophyton Linnæanum*. (Linnarsson, Geol. Mag., 1869, vi. 393.)

T. STERRY HUNT

SOCIETIES AND ACADEMIES

LONDON

Zoological Society, May 7.—Prof. Newton, V.P., F.R.S., in the chair. The secretary read a report on the additions that had been made to the society's collection during the month of March, 1872, amongst which were two red-necked bustards (*Eupodotis denhami*), presented by Mr. C. D. O'Connor and Governor Ussher, and a Beatrix antelope (*Oryx ebatrix*) from the Persian Gulf, received on deposit.—Mr. P. L. Sclater exhibited and made remarks on a skull of the Hairy Tapir of the Andes (*Tapirus roulini*) obtained by Mr. Buckley during his recent expedition to Ecuador.—Prof. Owen read the eighteenth of his series of memoirs on the extinct birds of the genus Dinornis and its allies, in which was contained the description of the pelvis and bones of the leg of *Dinornis gravis*, a supposed new species allied to *D. crassus*, and a general *résumé* of the described species of the genus *Dinornis*.—The Viscount Walden, F.R.S., communicated an appendix to his paper on the birds of Celebes, read at a former meeting of the society, and containing an account of twelve species to be added to the Celebean Avifauna. This raised the total number of known species of Celebean birds to 205.—Mr. Henry Buckley exhibited the eggs of three species of North American birds, which he believed had never previously been obtained. The eggs were those of *Falco polyagrus*, *Elanoides furcatus*, and *Ictinia Mississippiensis*.—Mr. H. E. Dresser exhibited the egg of *Querquedula marmorata*, collected in Spain by Major Irby, this being probably the first authenticated instance of the breeding of this bird in Spain.—A communication was read from Mr. W. H. Hudson, containing field notes on the habits of the swallows, of the genus *Progne*, met with in the Argentine Republic. To this was added some notes on the species by Mr. P. L. Sclater.—A communication was read from Mr. G. French Angus, containing descriptions of ten new species of land and marine shells, mostly from Australia.—A second communication from Mr. Angus contained the description of a new species of *Voluta*, proposed to be called *Voluta hargravesi*.—A paper by Mr. H. Adams was read, in which he described a new species of *Geotrochus* from the Island of New Britain, proposed to be called *G. fergusoni*.—A communication was read from Dr. J. E. Gray, F.R.S., containing a description of *Peltastes forsteni*, a species of land tortoise from Celebes.—Two communications were read from Mr. J. M. Brazier, giving descriptions of land and marine shells collected in Australia and Lord Howe's Island.—A communication was read from Mr. A. Anderson, containing some additional notes on the Raptorial birds of North Western India.—A paper by Dr. J. E. Gray, F.R.S., was read, describing a young Tapir from the Peruvian Amazons, which he proposed to call *Tapirus terrestris peruvianus*.—A communication was read from Dr. J. E. Bowerbank, F.R.S., containing the third part of his contributions to a general history of the *Spongiadæ*.